From a study of the literature of spinal cord tumors we believe our case to be unique for several reasons: 1. It is the only tumor of the spinal cord affecting the *upper cervical region* which has been so far recorded. 2. It is the only cervical cord tumor which has gone on to an uninterrupted course toward recovery. 3. It was definitely located and quickly removed without sacrifice of spinous processes and laminæ, and the short incision made a remarkably rapid closure. 4. The involvement of the phrenic nerve added an element of danger which was quickly removed during the progress of the operation. 5. From the surgeon's standpoint, it was located in the most inaccessible portion of the spinal cord, by virtue of the cervical curvature of the spinal column offering a concave field for operation instead of a convex.

STUDIES OF OVARIAN EMBRYOMATA, OR SO-CALLED OVARIAN DERMOID CYSTS.

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Everyone who has had the good fortune to study a series of ovarian cysts has found a certain small percentage of them to belong to the so-called dermoid variety. According to Olshausen, about 3½ per cent. of the ovarian cysts are of this kind. The so-called dermoid cysts of the ovary have given rise to so many conflicting views as regards their origin and structure that the literature is full of all kinds of polemics of which they are the subjects. Many of the older theories, themselves, seem to-day to be pathological curiosities. New theories as to their origin have, therefore, been received with a certain amount of reserve. The works of Pfannenstiel,[1] Kroemer,[2] and Wilms,[3] however, seem to have approached more nearly an ultimate solution of the problem than any that have appeared.

It is not the intention of this paper to introduce any new speculations concerning the origin of these tumors, but to describe as accurately as possible three so-called dermoid cysts of the ovary which have come to my hands for pathological diagnosis through the kindness of Dr. D. P. Allen, who removed them. Fortunately these three cysts represent quite distinct and separate features of this kind of new-growth in the ovary, and the study of them has yielded pathological findings similar to those described by Pfannenstiel, Kroemer, and Wilms.

Before beginning the description of these specimens it would seem proper, therefore, to mention briefly some of the conclusions reached by these men, which are exemplified by my pathological findings.

Wilms[3] showed that the so-called ovarian dermoids are to be held distinctively separate from the true dermoid cysts found in the head, neck, thorax, and other parts of the body. He also showed that the "embryome" or "zotte," which is the actively growing, or dynamic, portion of the cyst has representative tissues from each of the three primordial germinal layers, the ectoderm, the mesoderm, and the endoderm; that the order in which these tissues is produced is similar to the physiological process in the formation of the embryo. Accordingly, the skin, hair, teeth, etc.—ectodermal products principally—are the most conspicuous and most highly developed in the "embryome," while the visceral organs are seldom represented; for in the embryo the ectoderm and the cephalic end are differentiated and more highly organized long before the "anlage" of the splanchnic organs and the caudal end are differentiated. Further development to the complete embryo is soon turned aside by the hindrances of pressure and want of space, so that degenerative changes set in and pathological processes supervene which preclude any further development of the embryo as such. By stopping the process of development, thus, at any early stage, when the ectoderm is fairly well developed, the mesoderm less so, and the endoderm represented probably by merely a single layer of cells, it is evident that the last may be overlooked. Hence, it is easy to understand why, in some observations, the absence of representatives from the three primordial layers has been maintained, though a careful microscopic search will show them.

In the normal embryo there is an individual circulatory system very early in the life-history of the organism which is entirely separate from that of the mother, though it receives its soluble nutriment in the plasma through the placenta. In the so-called dermoid of the ovary, on the other hand, there is no placenta, nor is there even any decidual membrane formed in the uterus of the mother, which is one important point that serves to distinctly mark these structures from ovarian or abdominal pregnancies, in which cases an uterine decidua is always formed. The vascular system of the so-called ovarian dermoid is in direct continuity with that of the host without the intervention of a placenta, though, to be sure, new bloodvessels are formed as in all newly developing tissues, and in some cases even a more or less rudimentary bone-marrow is present which may subserve in a small way to the new-formation of blood corpuscles. Such a bone-marrow is found in Specimens 1 and 2.

Wilms then naturally comes to the conclusion that the so-called dermoid of the ovary is not of dermal origin, and is not a true dermoid, but he speaks of the new-growth as a "rudimentary ovarial parasite."

The Germans have referred for a long time to the actively growing portion of these cysts as the "embryome," in order to distinguish them from the true dermoids, which name they reserve for congenital cysts containing skin, hair, etc., found elsewhere in the body and of different origin. A good translation of this term into English is "embryoma," and I shall use this in referring to the actively growing portion of the cyst in the following descriptions in contradistinction to the whole ovarian cyst, cyst wall, etc.

Pfannenstiel[1] and Kroemer[2] came to the conclusion that the embryoma is of ovulogenous derivation, and that it is not due to a maldevelopment of Pflüger's plugs or cell-nests; nor is it an example of parthenogenesis. They limit parthenogenesis to the physiological process by which a living individual is produced asexually for the purpose of maintaining a species. Pfannenstiel asserts that while the "embryoma" develops from the ovum, the cystic portion of the tumor is derived from the walls of the Graafian follicle.

Dr. J. G. Clark[4] reviews Kroemer's original work, and criticises it very favorably in *Progressive Medicine*, saying in conclusion: "It seems to me that Kroemer has furnished very strong arguments in favor of this theory, and if all his observations can be substantiated there can be no longer any doubt as to its correctness."

Kroemer comes to a full agreement with Wilms, who first offered substantial proof concerning the ovulogenous development of these tumors.

In describing the anatomy of these specimens it would be fruitless, and also beyond the limits of this paper, to go into minute details in respect to the shape assumed by each kind of tissue present, and all the details of its histology, since that would cover the greater part of a treatise on histology, for almost all of the principal tissues of the body are represented in these growths. Also, macroscopically the anatomy of each embryoma differs in greater or less degree from every other one. Therefore, only the more important findings which are characteristic of this kind of new-growth will be described. Also, the macroscopic and microscopic descriptions will not be completely separated, since the aid of the one will be called upon to elucidate or support the findings of the other. Where a conclusion may be drawn from the condition of a tissue found, it will be mentioned immediately, rather than separate these remarks from the picture in question.

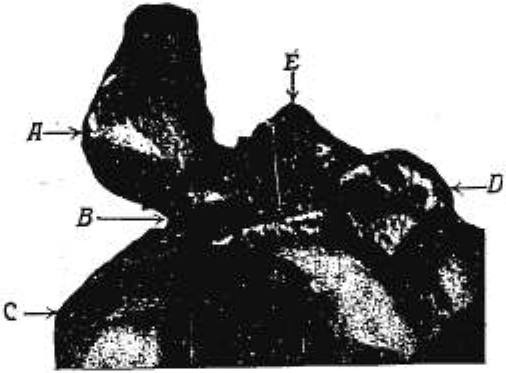
Description of Three Cysts and Their Contents.

Specimen 1 (Fig. 1) was removed from Mrs. H. A., aged forty-eight years, nationality Russian. She had had eleven living children and two miscarriages. Family and personal histories unimportant, with the exception that sixteen years ago the patient was told she had a tumor in the pelvis about the size of a lemon. This increased gradually in size until some years later, when she began to feel the tumor herself above the brim of the pelvis. The tumor caused no pain, nor did it interfere with repeated pregnancies.

The tumor was removed July 28, 1902, by Dr. Allen, on account of pressure and urinary disturbances it was causing.

Macroscopically the tumor is found to be a cyst of the right ovary, measuring 13 cm. in diameter and of 1½ litres content. The exterior of the cyst is of a dull yellowish white, in places shading into a bluish color. The surface is for the most part smooth, only here and there roughened by a few small tabs of fibrous adhesions. The right ovary and tube are adherent to the cyst, and also a portion of the fimbriated end of the left tube is adherent. Dark-blue bloodvessels can be seen radiating throughout the surface; they do not appear to be deeply situated in the cyst wall, but rather superficially. No inflammatory process, either past or present, can be made out in the ovary or tube. The former has a smooth exterior, except where attached by one pole to the large cyst; the latter is adherent only in part of its course, and its fimbriated end is free and patent; the lumen contains no pus. The wall of the cyst is very tough and leathery. In one place there is a small, thin area through which a hard body can be felt in the interior.

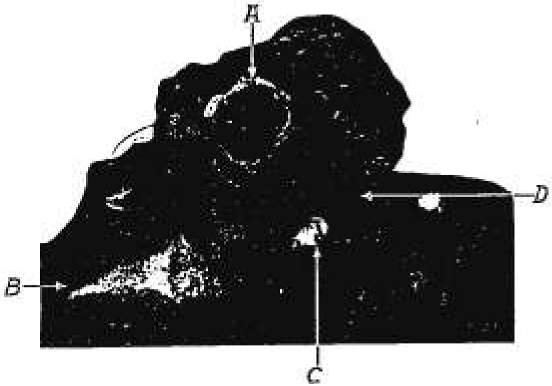
FIG. 1.



Specimen 1. Exterior of a portion of the cyst and adnexa. *A.* Cystic ovary. *B.* Bridge of tissue joining the cyst to a pole of ovary. *C.* External surface of cyst showing a few dark shadows of bloodvessels. *D.* Fallopian tube near uterine end. *E.* Fallopian tube near fimbria. (Natural size.)

The lumen of the cyst is found to be unilocular, and to be filled with a thick, brown, pasty mass that has a faint aromatic odor. This mass has a very greasy consistency when rubbed between the fingers. When exposed to the air at room temperature it rapidly solidifies and looks like beef fat or suet. Under the microscope it is composed of round balls of highly refractile, white-looking material. These balls or droplets dissolve readily in ether and warm alcohol, but separate out in cold alcohol or water. No crystals of cholesterin or other crystalline bodies are present. No leucocytes or other cells are seen, and no bacteria are found in the cover-slip preparations. Cultures tried on the usual media proved to be sterile. In the midst of this pultaceous mass is a ball of tangled, coarse, blonde hair. Almost all of the hair is found loose in the cavity, and is not attached to the inner surface of the cyst. The inside lining of the cyst does not resemble skin, nor does it appear capable of bearing hair. Therefore, this large amount of hair must have been produced from the single point on the inside of the cyst wall from which the embryoma or "zotte" protrudes. Also, the fatty, sebaceous-like material derives its origin from the same source.

FIG. 2.

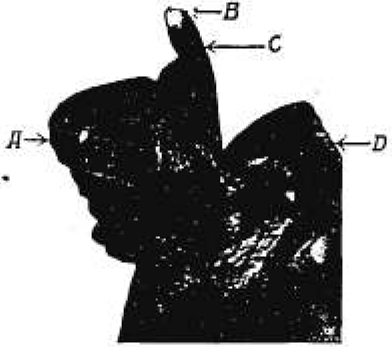


Specimen 1. Showing the embryoma everted through an opening in the cyst wall. *A.* Lip of ostium to the sac-like cavity in the embryoma. *B.* Cyst-wall, opened to show embryoma. *C.* Bicuspid tooth. *D.* Portion of the bone underlying soft parts. The black arrow indicates the direction of the transverse section surface shown in Fig. 4. (Natural size.)

Projecting into the cyst lumen from its inner surface at a point 10½ cm. from the connection of the cyst wall externally with the ovary is a mass of bone and soft tissue. (Fig. 2.) This mass forms the "embryoma," and measures in this case 4½ x 3½ x 2 cm. A well-formed bicuspid tooth is seen projecting conspicuously from an exposed portion of the bone. The bony portion of this structure is situated next to the cyst wall and underlies and supports the soft parts which cover the aspect turned toward the cyst lumen.

The shape of the bone is curved, the convex surface being turned toward the cyst wall. (Fig. 3.) This surface is completely flattened and smoothed. At the apex or the most prominent portion of the bone is situated a large bicuspid tooth. Now, at the first glance one is struck by the apparent resemblance of this portion of the bone to the lower maxilla in the adult. Due to its curved shape and the insertion of the tooth at the end, the total effect is that of an atrophied mandible in an old person who still possesses a single front incisor tooth, with the molar and bicuspid teeth lacking and an atrophied thin jawbone remaining.

Fig. 1.



Specimen 1. Another view of the embryoma showing the curved bone having the same curvature as the cyst wall. *A*. Embryoma, upper surface near the mouth of the cavity. *B*. Bicuspid tooth at apex of the bone. *C*. Convex surface of curved bone. *D*. Cyst wall. (About natural size.)

It is not the intention here to draw a close morphological comparison between this specimen and the senile lower jaw, but simply to show how far the imagination of the describers of many such specimens in the past has led them astray.

Some of the forces which produced the shape of this bone are made evident by noting its relation to the cyst wall. The curvature of the bone is that of a segment of a circle exactly coinciding with the inner surface of the cyst wall. The side of the bone next to the wall of the cyst is perfectly smooth and polished, and fits into a depression of the wall, which has likewise a smooth bottom. This depression in the wall has the exact outline of the bone, and serves as a matrix into which it is set. There is no organic union between the bone and the cyst wall over this area, so that it is evident that the bone did not originate from the cyst wall, but is a lateral growth from the embryoma. It was through this thinnest portion of the wall that a solid body could be felt from the outside. When held up to the light one could almost see through this portion of the wall, it was so thin and translucent. In short, this thinnest area was produced by local atrophy, due to pressure on part of the bone. The surface of the bone, on the other hand, was made smooth and moulded so as to conform with the curvature of the cyst. The side of the bone toward the cyst lúmen was free to develop, and hence had a more irregular outline, and at one point a tooth was produced. This tooth, however, is a bicuspid tooth, though it is in a position usually occupied by an incisor tooth, if this were, in reality, an attempt to form the lower maxilla. The side of the bone turned toward the cyst cavity was covered with a thin membrane, probably periosteum, while that facing the cyst wall was bare bone. Hence, the shape assumed by this bone was not due to a mimicry on the part of the embryoma to produce an organ similar to that found in the adult body, but it was moulded by external forces, to which it finally succumbed and resulted in a good example of pressure atrophy.

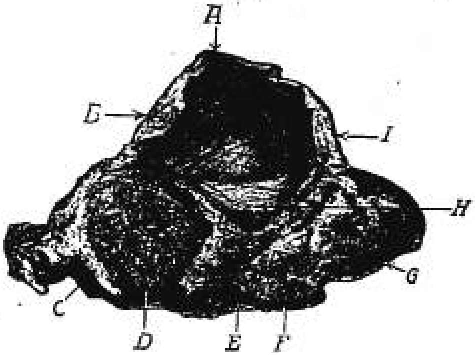
The soft parts are covered with a very coarse, hairy skin. The mouths of the large sebaceous glands are distinctly visible to the naked eye. The hair, however, has almost entirely fallen off. Directly above the point where the tooth appears in Fig. 2 is a globular, sac-like body, with a large round, smooth mouth. The wall of this structure is over 2 mm. thick, and is covered on the outside with fairly normal looking skin, which contains hair follicles, sebaceous and sweat glands. At the margin or lip of the ostium of this pouch a direct transition to smooth squamous epithelium void of hair or sebaceous glands takes place, and reminds one of the transition in the epithelium of the normal human lip. This same mucous epithelium lines the entire inner surface of this small cavity, which measures 2½ x 2 cm. A cross-section of it may be seen in Fig. 4.

The wall of this cavity is constructed of fibrous and fatty tissues which surround the sebaceous glands that open toward the outer or skin surface, while the little cushion of fat and loosely held together connective tissue bulges toward the cavity on the inside.

The complete microscopic study of this specimen was greatly embarrassed by the profound hyaline degeneration that had taken place in the soft tissues, so that only good microscopic pictures could be obtained of the firmer tissues, bone, cartilage, and dentine. The reason for this hyaline transformation will be considered below.

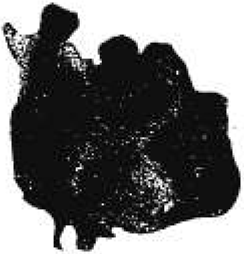
A distinct zone of well-developed hyaline cartilage was found between the bone on the lower side and the soft structure above. Between the cartilage and soft tissue a narrow strip of fibrous tissue could be seen. The bone presented near the centre a well-formed medullary cavity filled with fat, red blood cells, and leucocytes of various kinds. This cavity was crossed by a few trabeculæ of cancellous bone.

Fig. 4.



Specimen 1. Cross-section of embryoma taken in a plane indicated by the black arrow in Fig. 2. *A.* Lip of ostium. *B.* Skin and hair-bearing surface, also showing a fat cushion bulging toward the interior of the cavity. *C.* Solid laminated bone. *D.* Bone-marrow. *E.* Site where corpora amylacea were found. *F.* Site of a large mass of cartilage. *G.* Cancellous bone. *H.* Internal surface of sac-like cavity lined with mucous epithelium. *I.* Skin surface of embryoma furnished with sebaceous glands and hair follicles. (Enlarged about twice natural size.)

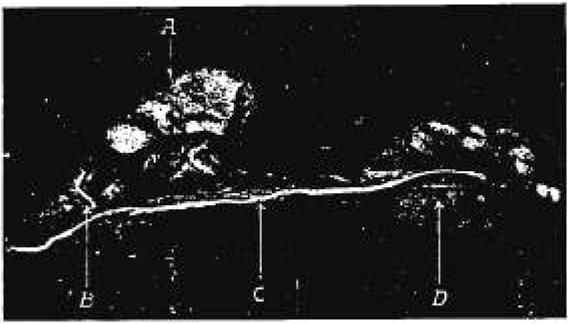
Fig. 5.



Specimen 1. X-ray photograph of embryoma showing five more teeth besides the one exposed bicuspid tooth at the top, which is the only one seen in the other photographs. (Natural size.)

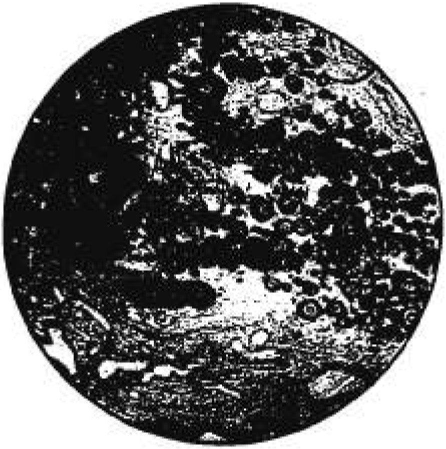
At the point indicated in Fig. 4, *E*, a large group of corpora amylacea was found. As many as 175 were counted in one field of the microscope with low-power objective. Some of the sections were stained in various ways so as to make sure of their composition.

FIG. 6.



Specimen 1. Showing the cyst wall intervening between and serving to join the ovary with the embryoma. *A.* Cystic ovary. *B.* Fimbriated end of Fallopian tube. *C.* Thin edge of cyst wall joining the embryoma to the ovary. The ovary extends on the external surface of the cyst wall, while the embryoma is situated on the inner surface and bulges toward the cyst lumen. *D.* Embryoma. (Reduced in size.)

FIG. 7.

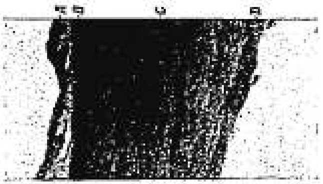


Specimen 1. Corpora amylacea found at point indicated in Fig. 4, *E.* (Magnified about 80 times.)

They reacted typically to the iodine and sulphuric acid test, first made known by Virchow in 1854. Also, typical reactions were obtained with methyl violet and methyl green. That they also contained some calcareous material was evident from the avidity with which they absorbed hæmatoxylin. This fact suggested the possibility of their relationship to the psammoma bodies of the central nervous tissues, though in this case they were found in a degenerated glandular tissue. Morphologically, the usual hyaline-like layers were seen to be deposited around a bright, central, highly refractile nucleus, the whole body having a concentrically laminated structure.

These bodies were described first by Morgagni, in 1723, and have since, from time to time, given rise to much discussion concerning their nature and origin. Exhaustive studies on this subject may be found in the works of H. Stilling[5] and Ferdinand Siegert.[6] The general consensus of opinion is that they are found in senile tissues more abundantly than elsewhere, as in the central nervous system, lungs, and prostates of old men, and that the tissues in which they are found have undergone atrophic degenerations.

FIG. 8.



Specimen 1. Section through cyst wall near the ovarian attachment. *A.* External surface of cyst wall, with remains of ovarian tissue. *B.* The line marking theca externa. *C.* Theca interna increased greatly in thickness by fibrous tissue, which is poor in bloodvessels. *D.* Layer of cells similar to corpus luteum cells.

The most interesting feature of this specimen is the fact that the embryoma is situated 10½ cm. from the ovary which gave rise to it, as was mentioned above. The only connection of this body, which is considerably larger than the ovary, with the pole of the ovary which gave rise to it is by means of the thin cyst wall. This suggested the question: "From whence did the embryoma receive its blood supply and nutriment during the last sixteen years of its existence?" For we were assured by the patient that the cyst was the size of a lemon sixteen years ago. Thereupon, serial sections were cut out of the short pedicle between the ovary and the cyst, and also many sections were taken from the cyst wall lying between the ovary and the embryoma, with the view of searching for the blood supply. It was found that there were very few bloodvessels present in the pedicle, and still less in the cyst wall, scarcely sufficient to supply the latter, much less the embryoma. The structure of the cyst wall was found to correspond with that of the ordinary corpus luteum cyst and to show two distinct fibrous layers of the theca externa and theca interna, the latter being very poor in bloodvessels, and in some places showing marked hyaline degeneration.

The interior of the cyst was lined with several layers of large cells irregularly packed together, containing large pale nuclei that resembled the corpus luteum cells lining a corpus luteum cyst. Hence, it became evident that the embryoma had developed in a Graafian follicle at one pole of the ovary. That the cyst wall had not taken part in the production of the embryoma, but it had remained a passive factor in the process, and that the lumen of the cyst had merely taken the place of a receptacle into which the loose hair, squamous cells, débris, and excretions of the sebaceous glands of the embryoma had discharged themselves. Thus, the constant increase in the contents of the cyst had gradually distended its walls and increased the size of the cyst; by increasing the size and periphery of the cyst the embryoma had been gradually carried away from the pole of the ovary from which it originated. The constant pressure from within had caused tension on the cyst wall, with a gradual occlusion of the bloodvessels supplying the embryoma.

This cutting off of the blood supply would easily explain the general hyaline degeneration that had taken place in the embryoma.

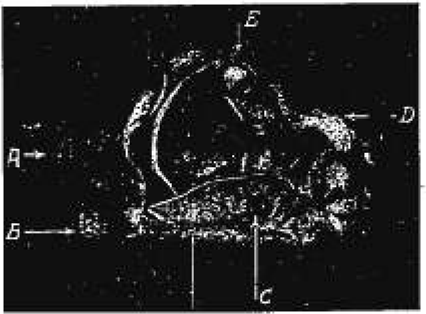
The X-ray photograph shows five more teeth besides the one large exposed bicuspid tooth. These teeth were inserted in the cancellous bone underlying the soft tissues, and had not yet cut through to the surface, and their presence was not discovered until the shadow was obtained on the X-ray plate. Sections were studied from the ovary which was removed with the cyst, and it was found to contain several small follicular cysts; two of them measuring over 1 cm. in diameter. There are no normal follicles to be seen in the cortical portion, and the stroma shows a general senile atrophy.

Specimen 2 was removed from Mrs. B. S., aged twenty-two years; nationality Russian. Family and personal histories unimportant until thirteen months ago, when she was in confinement. Since then she has complained of pain in the lower portion of the pelvis, which has greatly increased during the last six weeks. She was operated on May 23, 1902, by Dr. D. P. Allen, who removed a tubo-ovarian mass from the left side, which was greatly inflamed. This mass on fresh section was composed of clotted blood and a soft spongy tissue, which, on further microscopic study, proved to be an early tubal pregnancy. From the right side was removed the specimen here to be described.

The Fallopian tube on the right side is found to be normal. The ovary on this side is normal in size, measuring 4 x 4 x 3 cm., but is soft and studded with small cysts about the size of a pea. These were found later to be the maturing Graafian follicles. The surface of the ovary is white and glistening, and shows no signs of inflammatory reaction; there are no adhesions on this side. Upon section of the ovary it is found to be filled with a yellow, thick, semifluid material, which is quite greasy. Cultures grown in the usual media remained sterile.

After carefully removing this semisolid mass, in which were found a few loose hairs, a small portion of bone was exposed, in which was inserted a bicuspid tooth. Near one end of this plate of bone a soft, irregular spongy body was found covered with skin, from which protruded a small tuft of hair. The bony portion seemed to arise from one side of the cyst only, and occupied about one-third of the inner surface of the cyst; the latter was drawn over the remainder of the embryoma as a sac-like covering. In other words, this is the same condition as was found in Specimen 1, only in this case the cyst is much smaller in proportion to the embryoma. Here the embryoma fills almost the entire cyst lumen, and the greater portion of the embryoma, macroscopically, is seen to be composed of bone, while the skin and hair-bearing surface is reduced to a small area of about 1 x 1½ cm. In the former case, Specimen 1, the skin and hair-bearing surface was considerable, covering the greater portion of the embryoma, and, conse-

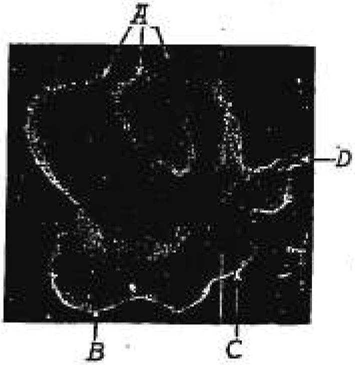
FIG. 9.



Specimen 2. Shows the ovary opened by a longitudinal incision. *A*. Fimbriated end of Fallopian tube. *B*. Fallopian tube. *C*. External surface of ovary and wall of cyst, showing small cystic follicles on uneven surface. *D*. Embryoma, with soft tissue and tuft of hair. *E*. Bony portion of embryo and single bicuspid tooth.

quently, the cast-off hair and excretions from the skin formed the largest and most conspicuous portion of the cystic contents. Here, then, is good evidence that the cyst lumen serves chiefly as a receptacle for the excretions from the dermal surface of the embryoma, and that the size and distention of the cyst are in direct ratio to the amount of waste products shed from the embryoma. The shape of the bone was fairly regular and disk-shaped, with two small undulating prominences, which, on comparing with the X-ray shadow, were seen to be the site of two teeth not yet cut through the surface. This was substantiated later by transverse microtome sections. This bony portion of the embryoma was covered with a thin, firm, smooth tissue that had a moist, sticky surface entirely void of hair and not resembling normal skin, but looked more like mucous membrane.

FIG. 10.



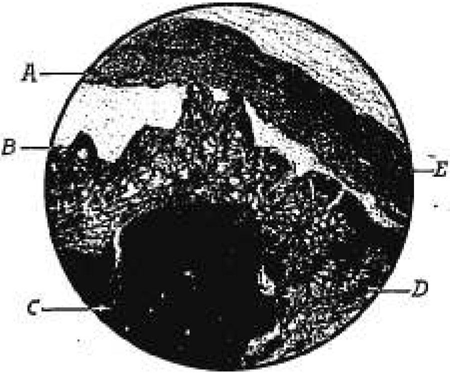
Specimen 2. X-ray photograph showing two more teeth in addition to the single bicuspid tooth in Fig. 9. *A*. The three teeth. *B* and *C*. Fallopian tube. *D*. Fimbriated end of Fallopian tube.

After this superficial investigation, the longitudinal incision through the cyst wall was tightly sutured, so as to restore as nearly as possible the relation of the embryoma to the cyst. The whole mass was then decalcified, and sections were cut.

Microtome sections were cut transversely to the long axis of the ovary through the cyst wall, soft parts, bone, and teeth. The cyst wall is seen to contain ovarian stroma in all portions, so that the embryoma, which is centrally located in the ovary and arises from the thickest part of the cyst wall, must have arisen in a Graafian follicle near the medullary portion of the ovary, and not in the cortical portion.

The soft parts are covered with a true skin at the end of the embryoma, from which the tuft of hair may be seen growing. This skin is remarkable in the great amount of comedone formation present. That is, the ducts of the sebaceous glands have become stopped, and minute retention cysts have formed, which have subsequently broken through to the surface, causing the skin to have a very rough, uneven, honey-combed appearance. The epidermis is normal, having a well-defined corneous layer, and shows the transition from squamous to polyhedral cells in the deeper layers. The corium is well developed and contains fibrous and fatty tissue, which is penetrated by the hair shafts springing from normal hair papillæ. The size and number of the sebaceous glands are far greater than normal, and hence, the condition may be looked on as an hypertrophy and proliferation.

FIG. 11.



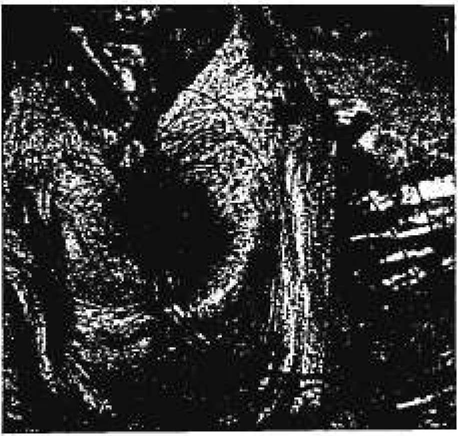
Specimen 2. Microscopic section through a portion of the cyst wall and embryoma. *A*. Cyst wall containing ovarian tissue. *B*. Epidermis of embryoma thrown into an irregular, broken surface by the comedone formation in the sebaceous glands. *C*. Firm lamellated bone showing Haversian canals. *D*. Corium of skin containing large masses of sebaceous glands. *E*. Cyst wall containing a long flattened corpus albicans in the ovarian tissue. (Magnified about 40 times.)

Around the bases of these glands is seen the fibrous tissue of the corium held together in loose bundles; in other places fat cells are more predominant.

In the corium are seen masses of tubular glands lined with a single layer of low cuboidal epithelium, with large round deeply staining basal nuclei. These cells rest on a firm homogeneous highly refractile narrow band of tissue that may be considered the membrana propria, which separates the gland tubules from the connective tissue of the stroma and from each other. These glands, without doubt, bear a strong resemblance to sweat glands; but, due to the great number of sebaceous glands above them, it is difficult to find ducts long enough to penetrate in one continuous line to the surface of the epidermis in one section, though cross and oblique sections of such ducts are frequently seen.

The soft parts at the other end of the specimen show a rather complex set of foldings and reduplications. Here the epidermis is quite thin, though of the squamous variety; it contains no papillæ, and is only four or six cells deep in some places. No glands of any description underlie this epithelium. There is a marked change in the surface, which rises up to form regular papillæ or villi, covered with low columnar epithelium, with round vesicular nuclei placed at the base of the cell. Where cross-sections of these villi are met they are seen to be uniformly round or oval in contour; and the epithelial cells rest on a fine basement membrane. The body or core of the villus consists of fibrous connective tissue regularly placed around small vessels. A few leucocytes and red blood corpuscles are seen in the meshes of the con-

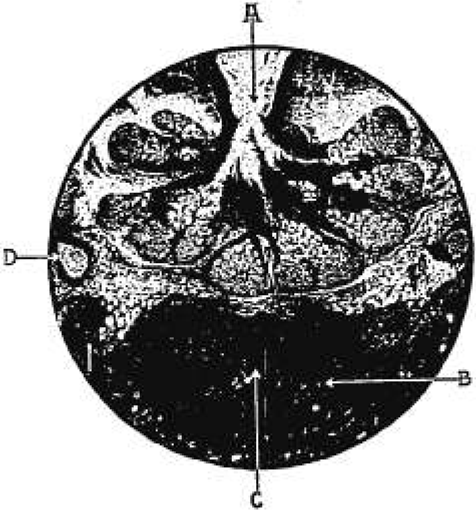
FIG. 12.



Specimen 3. Interior surface of cyst wall, showing the flattened embryoma. The tuft of hair is seen springing from the skin surface, which is dotted over with large mouths of sebaceous glands. (A trifle enlarged.)

nective tissue. These structures then resemble closely the villi of the small intestine. On following this undulating surface into some of the other folds, a transition from squamous epithelium to high columnar ciliated epithelium is seen. These columnar cells have large, oval basal nuclei. Between them are placed many interstitial cells, and the whole mucosa is bounded by a distinct limiting membrane. This tissue is seen to contain many small round deeply stained leucocytes, and in some fields of the microscope they are found massed together into structures resembling solitary follicles.

FIG. 13.



Specimen 3. Microscopic photograph showing representatives from the three primitive layers. *A.* Epidermis with the mouth of an immense sebaceous gland. *B.* Rudimentary thyroid gland containing colloid material in the acini. *C.* Large mass of lymphoid tissue. D. Bloodvessels in corium surrounded by fibrous and fatty tissue.

The more highly differentiated glandular structures found in the normal intestinal wall, like the glands of Brunner and the follicles of Lieberkühn, are absent.

The bone in this specimen is macroscopically irregular and of a nondescript form, but microscopically it contains all the structures of normal bone. A large portion of it has a cancellous structure, and the spaces are filled with red and yellow marrow. The teeth have all the structures found in normal teeth. The dentine is laid down in perfectly parallel dentinal tubules, and the pulp cavity is seen to contain normal bloodvessels and fibrous tissue.

The sections through the remainder of the ovary lying outside of the cyst wall show numerous Graafian follicles in various stages of maturity, and some of the follicles are so large as to become small cysts. These large follicles are situated in the cortex of the organ, but there is still considerable dense ovarian stroma separating them from the surface. It is rare to see so many apparently mature follicles and others rapidly approaching maturity in a single section as the sections from this specimen show.

Specimen 3 was removed from Miss I. W., aged twenty-five years; teacher; nationality American. Family and personal histories unimportant. During the last two years she has had some uterine trouble and has complained of increased frequency in menstrual periods, for which she received local treatment. On September 4, 1902, Dr. D. P. Allen removed the specimen, now to be described, from the left ovary.

This consists of a cyst measuring 12 x 9 x 7½ cm., or about the size ot a large orange, weighs 460 grammes, and is ovoid in shape, with a fairly regular outline. The exterior has a glistening, pale, yellowish-white color. No adhesions are present. The tube is firmly stretched over the cyst in the middle of its course, but both ends are free and patent. In short, there are no evidences of inflammation past or present.

The exterior of the cyst is of a light-yellow color, in places shading to a dark blue or purple. Immediately after removal the cyst appeared to contain fluid, and fluctuation of its contents was noted; by the time the operation was over, however, it had cooled down to room temperature, and was found to be much firmer than when removed; fluctuation could not be obtained, but the contents could be kneaded like putty. It was then evident, before the cyst was opened, that it belonged to the variety that we are now considering.

On opening the cyst it was found to be filled with a light-yellow, greasy material which resembled butter. This was thoroughly mixed with a tangled mass of dark-brown hair. Cultures grown on the usual media remained sterile.

The oleaginous portion of the cystic contents was easily soluble in ether and warm alcohol, but not in cold alcohol or water. When examined under the microscope it was seen to be made up of small, highly refractile balls or droplets. A portion of it was treated with a dilute solution of warm potassium hydroxide, and it was saponified. No cholesterin or other crystals were found, nor were there any leucocytes to be seen, but merely the desquamated epidermal cells and débris.

In this case the cyst was bilocular, that is, there were two large loculi; one, however, about twice the size of the other, contained the hair, and in this one the embryoma was found. The smaller cyst contained a thick, viscous fluid, partly mixed with the oily substance derived from the other cyst, for a small perforation was found in the septum between them.

The embryoma was found quite flattened against one side of the cyst, and appeared directly continuous with the ovary, which was flattened and stretched on the outside of the cyst. The shape of the embryoma was more irregular in this case than in either of the others, but, in general, it assumed that of a bar or bridge of tissue stretching across a segment of the cyst and having irregular expansions on the cyst wall at either end.

FIG. 14.

Specimen 3. X-ray photograph showing the small almond-shaped piece of bone with one tooth lying in the centre of the embryoma, which shows in lighter shadow.

The side of the embryoma turned toward the cyst lumen had a large superficial expansion, and was covered with hair and the mouths of large sebaceous glands. The lower or under side of the tumor was covered with a smooth, almost velvety epithelium, possessing no hair or visible gland orifices.

This embryoma is the smallest of the three, measuring 5 cm. long by 2.2 cm. wide, but has relatively the largest skin and hair-producing surface. The size of the cyst, though not actually so large as Specimen No. 1, was relatively to the embryoma very much greater. Here, then, was a large cyst with a relatively large skin and hair surface on the embryoma. In other words, this substantiated the fact above noted, that the cyst serves simply as a receptacle for the excretions of the embryoma, and where a large cyst is present a correspondingly large surface for the production of the cystic contents must naturally be expected. In Specimen No. 2 the skin and hair-producing surface was seen to be quite small; in that case the cyst did not go beyond the limits of a normal sized ovary. Only one hard, firm nodule, about the size of an almond, could be felt in the body of the embryoma. This was shown by the X-ray shadow to be composed of a small piece of bone and one tooth. (Fig. 14). No teeth were visible on the surface of the embryoma. The line of demarcation between the skin covering the embryoma and the interior surface of the cyst wall was very distinct.

In the macroscopic description it was noted that the embryoma was attached at either end to the cyst wall, but was free in the cyst lumen near its central portion. One of these ends was seen to arise opposite the point where the ovary was attached on the other side of the cyst wall; for the sake of convenience in the description this will be designated the proximal end of the embryoma, being nearest the ovary, while the other end will be referred to as the distal end. Microtome sections were begun at the proximal end and cut transversely to the long axis of the embryoma.

The first set of sections were carried through the ovary, cyst wall, and proximal end of the embryoma. The layer of ovarian tissue is seen to be very much flattened and thinned with the cells of the stroma densely packed together.

Next to this is the cyst wall, composed of dense strands of fibrous tissue laid in parallel bundles. The cyst wall in this case is the one most richly furnished with bloodvessels of the three specimens. A definite arrangement of the layers into a theca interna and theca externa can be made out as in the other two cysts.

The proximal end of the dermoid is composed chiefly of loosely packed connective tissue, which is well supplied with large bloodvessels. Some of the intervascular connective tissue is seen to be undergoing an apparent myxomatous change. In these areas the cells are seen to be greatly swollen, the cytoplasm being pulled out into long, thin processes, which take a very faint eosin stain. Some of the cells appear purple on account of the indifferent way in which they take both the hæmatoxylin and eosin. The nuclei still retain their staining properties, though they are large, pale, and vesicular.

In some places where the change is most extensive only the nuclei can be seen, the cytoplasm and intercellular substance no longer being differentiated by the stains. Such areas look very much like soft, medullary, sarcomatous tissue. The altered tissue does not appear malignant, however, and such changes in ovarian tissue and ovarian tumors are not uncommon. There are numerous small, round, lymphoid cells throughout this portion of the preparation, and here and there they may be seen massed into large groups that appear like lymph nodes. The upper and lower surfaces of the embryoma near the proximal end are covered with squamous epithelium; that on the upper surface is thicker than that on the lower, though no hair follicles or glandular structures are to be seen in this portion of the specimen.

The next block of sections was taken from the middle portion of the embryoma, and involved the soft parts and the bone discovered by the X-ray shadow. The upper surface or side of the embryoma turned toward the cyst lumen in these sections is that portion which is seen to be so richly supplied with hair. Here the epidermis is of normal thickness, but the corium is very much increased in depth on account of the large number of hair shafts and the great increase of sebaceous glands that dip down into it. A definite pigment layer is easily made out in the epidermis in this case. Below the sebaceous glands a narrow band of non-striated muscle is seen weaving its way in a wavy outline across the specimen near the fundi of the sebaceous glands. Bundles of nerve tissues are also easily made out. These bundles appear like the trunks of normal peripheral nerves, composed of axis-cylinder and myelin sheath. These bundles can be traced into the next set of sections taken from the distal end of the embryoma, in which ganglion cells are found.

Islands of cartilage of various sizes, with perfectly normal cells, are present. Some of these islands are long and narrow, and it is evident that an attempt has been made to form a chain of strips or islands of cartilage, but a complete ring has not been formed, such as occurs in a normal trachea. As the lower side of the section is approached (corresponding to the lower side of the embryoma), the connective tissue is less dense, and here and there is replaced by islands of fat. Large masses of lymphoid cells are also met. Finally the lower border of the section is seen to be covered with a single layer of ciliated columnar epithelium. The small section of bone in this specimen is quite dense, and no cancellous tissue is present. The arrangement of the lamellæ and Haversian canals is normal.

The third set of sections, involving the cyst wall and the distal end of the embryoma, shows the same great variety of tissues as the preceding sections. In addition, a rudimentary, mucous, salivary gland, showing all the details of the normal structure, including acini and tubules, is present. These tubules are quite distinct, and the acini are separated by a considerable amount of fibrous tissue; the definite racemose character of the glands is well marked.

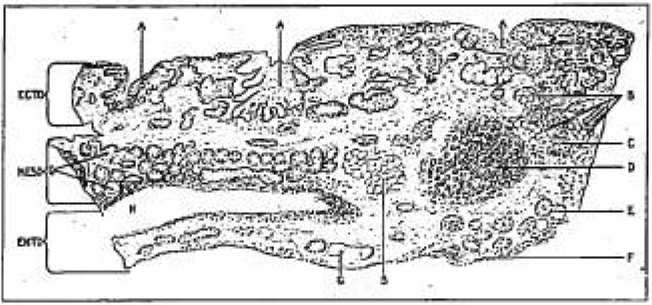
Tissue resembling normal thyroid gland, with well-marked spaces filled with colloid material, is present. One of the most interesting histological details of the sections from this part of the embryoma is the well-developed ganglion containing large nerve cells, such as are seen in the dorsal root ganglia of the spinal sensory nerves.

Space would not permit, here, to go into all of the histological details of the representatives of the various glands, tissues, and structures occurring in the upper portions of the respiratory and alimentary tracts found in this specimen. Such would be merely a repetition of well-known histological pictures.

Taking the general relation of these structures to one another into consideration, however, it is interesting to see that they had a fairly definite order, beginning with the ectodermal derivatives on the superior surface (the skin, hair, and sebaceous glands), followed by the mesodermal structures (connective tissues, bone, fibrous tissue, cartilage, etc.) near the centre of the embryoma, and finally furnished with the derivatives of the endoderm (the ciliated columnar epithelium, thyroid gland, and a structure similar to the intestinal canal) near the lower surface of the embryoma. (Fig. 15.)

The most extensively developed layer is the ectodermal, the least differentiated the endodermal.

FIG. 15.



Specimen 3. This is a photograph of a drawing made with a camera lucida of a section showing the representative tissues derived from three primordial layers. The outlines are perfectly preserved, though the nuclei were put in free-hand and show up too large in proportion to the magnification. *A.* Large sebaceous glands. *B.* Fat. *C.* Lymphoid tissue. *D.* Cartilage. *E.* Thyroid tissue. *F.* Ciliated columnar epithelium. *G.* Salivary gland tissue. *H.* Cavity lined with ciliated columnar epithelium. *Ecto*, *Meso*, and *Ento* represent in a general way the three zones of the embryoma in which representatives from the three primordial germinal layers may be found. (Magnified about 12 times.)

The cells representing these tissues are in every case as perfect of their kind as those found in normal adult organs; but, on the other hand, the organs themselves have in no case reached a normal and full completion. In other words, the picture produced is that of normal adult cells placed in the positions of embryoidal beginnings of organs. The necessary foldings and mechanical action in the migration of the various cells has not taken place. To use a military simile, one might aptly describe the position of these adult cells as one in which no mobilization had occurred, or in which they had not been mustered into their proper ranks.

The bizarre form assumed by the tissues of this and other specimens would then be explained as in Specimen No. 1, namely, that extraneous forces had so hemmed the development along normal lines as to sooner or later arrest the growth. Also, the fact must not be forgotten that here a large portion of the embryoma is held stationary against the cyst wall, so that the normal foldings and invaginations of the various tissues cannot take place as in the normal embryo, which is practically swung free in space in the amniotic fluid.

SUMMARY. 1. It has been shown in these specimens just described that, though each has an anatomy peculiar to itself, still there is much in common among them, and also that they are similar to the cases recorded by Pfannenstiel, Kroemer, Wilms, and others.

2. Structures derived from the three embryonal primordial layers were found in each of them, with the exception of the first, and here the microscopic search for the endoderm was prevented by the great degeneration of the tissues, so that only the coarser structures could be made out.

3. The extent of the development along different lines varied greatly in each case, though all of them were turned to pathological growth comparatively early when compared with the normal embryo.

4. The structure of the cyst wall was seen to be similar to other cysts derived from Graafian follicles.

5. The size of the cyst was independent of the size of the embryoma within certain limits, but the size of the cyst seemed to vary in direct proportion to the amount of waste matter excreted by the embryoma.

6. The remains of the ovary from which these specimens developed, as well as the organ on the opposite side, were found to be either cystic or to have an abnormally large number of follicles approaching maturity.

7. In none of the specimens were any fœtal inclusions, fœtal remains, or congenital malformations found, and that the rest of the genitalia of the hosts was normal with the exception of the cystitis in Case I., and the tubal pregnancy in Case II. So that the congenital formation of these tumors appears extremely doubtful.

It seems necessary to mention, however, for sake of completeness, that such congenital origin for these new-growths has been maintained by Bandler[7] since the works of Pfannenstiel, Kroemer, Wilms, Arnsperger,[8] and others of recent date have appeared. A review of Bandler's work is found in *Progressive Medicine*[9] of June, 1902, so that it will be unnecessary to go into detail concerning it here, but simply to mention that he tries to prove the origin of these cysts to come from the remains of the Wolffian duct and misplaced ectodermal cells.

The cause of this apparently spontaneous segmentation on the part of the ovum is an unsolved problem, as is the cause of the proliferation of certain other cells to tumor formation; but the process is considered to be an analogous one by some of the recent investigators on the subject.

Arnsperger[8] says: "The fact that the maximum for the frequency of dermoids coincides with the height of the sexual life is important. This fact then speaks more for the derivation of ovarian dermoids from the ripe ova. I believe that if all dermoids (of the ovary) were congenital, more would be found at the autopsies of children."

It is significant that in many cases of so-called dermoids of the ovary there have been various other cysts and new-growths in combination with them.

Klein[10] states that 14 per cent. of the ovarian embryomata are combined with other types of cysts of the ovary. He reports one case in which a threefold combination was present in the same ovary, namely, an embryoma, a colloid cystoma, and a malignant tumor. Niemer[11] also reports several cases of combination of dermoids with other cysts of the ovary.

A case of Simmerling[12] has been reported, in which a proliferating glandular ovarial cystoma was found complicated with a small carcinomatous dermoid cyst.

Pfannenstiel[13] goes further and says: "The same impulse which causes the production of malignant tumor formation induces the formation of the dermoid cyst. From the epithelium of the Graafian follicle develops a simple cystoma or a pseudomucin cyst." He says, in another place, that ovarian dermoids are most frequently found combined with pseudomucin cysts.

Wilms[14] says that when we bring the two tumor groups in relation to each other, the embryomata of the testis and the embryomata of the ovary, with tumors in general, then we must consider them the most complex of all tumors. In his last contribution to the subject Wilms* defines the so-called dermoid cyst of the ovary as follows: "The embryoma of the ovary is a tumor composed of a threefold germinal anlage ultimately derived from an ovum, which, during its development in a small cyst, is early arrested, and only succeeds to the rudiment of an embryo."

TECHNIQUE. When the macroscopic description of the first specimen was begun it became evident that it would be very much simpler to record the gross appearances of these bizarre tumors by means of sketches and photographs than by long verbose protocols; for in each instance there was an individual anatomy to deal with and no standard for comparison. Therefore, liberal use of the camera supplemented by explanatory sketches was employed throughout the study of them. The accompanying illustrations are some of the many views taken.

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* M. Wilms' definition of the embryo: "Das Embryome des Eierstockes ist eine aus einer dreiblättrigen Keimanlage in letzter Instanz, also aus einer Eizelle hervorgegangene Geschwulstbildung, welche durch die Entwickelung in einer Kleinen Cyste in ihrem Wachsthum frühzeitig gehemmt, nur zu einem Rudiment eines Embryo auswächst."

Since bone and teeth composed such a large part of the tumors, X-ray photographs of the specimens were taken in order to obtain the quantity and relation of the bone to the soft parts, and in each of them teeth hidden either in the bone or soft tissues were discovered. This proved of great value when it came to dividing up the material for microscopic study, and was the means of saving many a microtome knife; for, by comparing the specimens with the X-ray plate, one could tell exactly the points where to expect buried teeth and dense bone. Such pieces were left for a longer period in the decalcifying fluid.

On account of the close relationship of the bone, which was present in large masses, to the soft parts, it was necessary to decalcify the former without injury to the latter.

Most of the methods of decalcifying teeth and bone in large pieces, found in the various books on laboratory technique, do not give perfectly gratifying results in all respects. Either the bone is sufficiently decalcified and the staining characteristics of the soft tissues sacrificed, or the bone remains too hard to cut, and the soft parts are preserved. The weak solutions of acids take entirely too much time in the routine preparation of large pieces of bone for microscopic study, and daily changing of the decalcifying fluid is necessary over a period of several months. The use of phloroglucin as a protective with very strong acid is expensive, on account of the comparatively high price of phloroglucin as a laboratory reagent, and a long period of washing is necessary to remove the excess of acid, so that this method is not altogether satisfactory for large pieces of bone.

The ideal method for decalcifying bone and teeth, then, is one in which the insoluble organic salts may be removed in a short period of time, leaving the soft organic structures in their natural forms without marring the staining properties of the cells.

In preparing the above specimens for microscopic study the following steps were taken:

1. The specimen was hardened *en masse* by placing it in Orth's fluid for three to four days.

(Orth's fluid = Müller's fluid plus 4 per cent. formaldehyde.)

2. Washed in running water for twenty-four hours to remove the excess of this fluid, since a dark brown precipitate occurs in tissues left too long in Orth's fluid.

3. Removed from the running water and placed directly in the following decalcifying fluid:

Pure nitric acid from 75 c.c. to 100 c.c. (according to the density and size of bone, and the speed desired in decalcification); alcohol (95 per cent.), 750 c.c.; distilled water, 250 c.c.; sodium chloride, 7½ grammes.

This is a slight modification of von Ebner's decalcifying fluid.

The fluid was made up in this manner in quantities. The specimen was placed in a glass jar fitted with a tight screw top, to prevent loss of the alcohol, containing from 150 c.c. to 200 c.c. of this fluid at a time, according to the size of the specimen. The fluid was changed on an average of every four to five days until complete decalcification was obtained. This was ascertained by thrusting a fine needle into the portions of the specimen where the X-ray shadows indicated the firmest bone and teeth.

4. The specimen was transferred from the decalcifying fluid to the alkaline neutralizing fluid, composed of: aqua ammoniæ fortior, 10 c.c.; alcohol absolute, 90 c.c. It remained in this fluid twenty-four hours.

5. Alcohol and ether in equal parts.

6. Embedding in celloidin as usual, etc.

The results obtained by this method were very gratifying, not only in the sections obtained of the above specimens, but also of bone from other sources, such as osteomyelitis, epiphysitis, and teeth. The advantages of this method are in a general shortening of several of the steps usually taken in decalcifying, the uniformity in which the decalcification takes place, and the perfectly retained staining properties of the soft tissues.

It will be noticed that after hardening in Orth's fluid and washing in water the specimen is transferred directly to the decalcifying fluid. By the other methods usually employed the partial softening and swelling of the tissues incident to washing after Orth's fluid has to be overcome by a second hardening in alcohol before the decalcification process is begun. This, of course, takes time.

By using a decalcifying fluid that contains a high percentage of alcohol this is not necessary, for the alcohol in the decalcifying fluid serves as a hardening reagent to the soft parts, while the solid inorganic salts are attacked by the acid. Also, the presence of the NaCl in a quantity sufficient to bring the density of the fluid to about that of normal salt solution is a great protection to the soft parts, since it prevents the setting in of strong diffusion currents through the tissues, and the imbibition of water which would tend to swell and distort the cells.

Instead of removing the excess of acid by a prolonged washing of the specimen in running water, as is usually the custom, it is transferred immediately to a stronger alcoholic solution made alkaline by ammonia.

This is not only a saving of time in this step of the process, but also makes it unnecessary to submit the tissue to the dangerous process of too long washing and swelling of the decalcified tissues by imbibition. Ordinarily after such washing the specimens have to be rehardened by carrying them through graded alcohols before embedding. I believe that tissues are almost as frequently spoiled in decalcification processes by transferring them from alcoholic to aqueous solutions, and in and out of hardening and decalcifying fluids of different osmotic equivalents, as they are by too long contact with acids, or by using too strong acid solutions. The above decalcifying fluid varies from von Ebner's fluid in the use of HNO_3 instead of HCl, and in different proportions of the other ingredients.

By using an ammoniacal strong alcoholic solution to neutralize the excess of acid much time is saved, and the specimen is kept continually in a hardening fluid from the time it leaves its initial washing following Orth's fluid. The use of ammonia is preferred also to that of other alkaline reagents, such as $CaCO_3$, $NaHCO_3$, etc., since it may be used in almost any desired concentration and excess without injuring the tissues and without introducing an alkaline reagent that might reprecipitate some of the mineral salts which have been dissociated by the acid, but which may still remain in the tissues.

The extreme solubility of most ammoniacal salts precludes this. Also, a mineral alkaline body, if left in the tissues in excess, would interfere with the subsequent staining, since tissues should be neutral in reaction, in order to obtain satisfactory histological stains. The excess of ammonia, however, completely evaporates by the time the specimen has been carried through the alcohol and ether and embedding process and has been sectioned ready for staining. In several cases after the sections had been cut they were placed in a bottle with a small quantity of water, and vigorously shaken, so that any excess of free ammonia would be washed from them. This wash-water was then tested with litmus paper, and was found to be neutral.

Another characteristic of this process is that when this specimen is transferred from the decalcifying fluid, containing the nitric acid, to the neutralizing fluid, containing the ammonia, a bright-yellow or orange color is given to the specimen. This color is due to the well-known xanthoproteic reaction, which takes place in proteid bodies when treated with these reagents. This color, however, does not in any way detract from the staining of the cytoplasm of the cells with eosin. In fact, in many of the sections advantage was taken of this color reaction as a contrast to the nuclear stain, and then only hæmatoxylin was used. Whether this yellow color will persist or not, as eosin will for a long time, is doubtful.

In describing Specimen 1, it was stated that the whole embryoma had undergone such profound hyaline degeneration as to prevent a satisfactory microscopic study of it. At first it was feared that this hyaline degeneration might be an artefact caused by the strong decalcifying fluid, so a portion of the soft tissues from the other half of the embryoma and cyst wall that had not yet been decalcified was cut from the bone and carried through in the ordinary manner for soft tissues without coming in contact with the decalcifying fluid as a control test. When this was cut and stained it was found to behave toward the staining reagents in the same manner as the portion that had been decalcified. This proved that the decalcifying fluids had nothing to do with the poor staining properties of Specimen 1, but that a true hyaline degeneration had taken place.

Specimens of bone and teeth from various sources, combined with more or less soft tissues, have been decalcified by this method in pieces of 1½ cm. square in less than three weeks, which would have taken at least six to eight weeks by the ordinary methods, and they have retained their staining properties perfectly.

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